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Agilent No. 10972039-2
R&A No. 5000-0029
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#11/Appeal
Brief

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of:
Reid A. BRENNEN et al.

Serial No.: 09/233,694

Group Art Unit: 1756

Filing Date: January 19, 1999

Examiner: C. Young

Title: METHOD FOR PRODUCING HIGH-SURFACE AREA TEXTURING OF A
SUBSTRATE, SUBSTRATES PREPARED THEREBY AND MASKS FOR USE
THEREIN

APPEAL BRIEF TRANSMITTAL

Director of Patents and Trademarks
Washington, D.C. 20231

Sir:

Further to the Notice of Appeal filed January 19, 2001, transmitted herewith for filing in the above-identified patent application is an Appeal Brief in triplicate. A check for \$310 to cover the fee is also enclosed.

The Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§ 1.16, 1.17, and 1.21 which may be required by this paper, or to credit any overpayment, to Deposit Account No. 18-0580. **A duplicate copy of this sheet is attached.**

Respectfully submitted,

March 15, 2001
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BRIEF FOR APPELLANTS

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BRIEF FOR APPELLANTS

INTRODUCTION

This is an appeal from the final rejection in the above-captioned case, dated September 22, 2000. In that communication, Examiner Young in Group Art Unit 1756 finally rejected claims 23-27, 29-46, 48-50, 52-69, 77 and 78 under 35 U.S.C. §102(b) as anticipated, or alternatively under 35 U.S.C. §103 as obvious.

Appellants responded to the rejection by submitting the declaration of Reid A. Brennan pursuant to 37 C.F.R. §1.132. On December 8, 2000, an advisory action was mailed stating that the declaration and request for reconsideration were unpersuasive because "the closest prior art of record has not been utilized for comparison purposes." A Notice of Appeal was filed on January 19, 2001.

REAL PARTY IN INTEREST

As assignee of the entire right, title and interest in and to the above-mentioned invention, Agilent Technologies, Inc. is the real party of interest in this appeal.

RELATED APPEALS AND INTERFERENCES

Appellants are unaware of any appeals or interferences related to this case.

STATUS OF CLAIMS

All pending claims, claims 23-27, 29-46, 48-50, 52-69, 77 and 78 stand finally rejected under 35 U.S.C. §102(b) as anticipated by, or, in the alternative, under 35 U.S.C. §103(a) as obvious over either one of U.S. Patent Nos. 5,638,413 to Kaltenbach et al. or 5,571,410 to Swedberg et al. In addition, the Examiner relied on inherency as a basis for the combination rejection.

STATUS OF AMENDMENTS

During prosecution of this case, a restriction requirement was issued resulting in the withdrawal of claims 1-22, 28, 47, 51 and 70-76 from consideration. In addition, an amendment was submitted in response to the Office Action mailed on May 22, 2000. The amendment clarified that the process by which the claimed substrate is formed increases the substrate surface area by at least 10-fold to 100,000-fold. high-surface area textured substrate. In addition, claims 77 and 78 were added to recite that the initial surface area of the substrate may be increased by 1,000-fold to 100,00-fold and 10,000-fold to 100,000-fold, respectively. No other amendments were submitted. Thus, as discussed above, claims 23-27, 29-46, 48-50, 52-69, 77 and 78 are pending on this appeal and are listed in their amended form in the Appendix.

SUMMARY OF INVENTION

The claimed invention relates to a high-surface area textured substrate prepared by a process involving subtracting a material from, adding material to, or both subtracting material from and adding material to a surface of a substrate. As a result, the surface is textured and has an area that has been increased by at least one order of magnitude. That is, the surface area of the substrate is increased by at least 10-fold to 100,000-fold as recited in claim 23. The initial surface area of the substrate is preferably increased by at least 1,000-fold to 100,000-fold as recited in claim 77 and optimally increased by at least 10,000-fold to 100,000-fold as recited in claim 78. Such surface area increase may be achieved, e.g., through lithographic and laser ablation techniques. In particular, examples of such textured surfaces achieved through laser ablation are illustrated and described, e.g., in FIG. 4A-H and accompanying text of the application, respectively. These figures illustrate a "coning" process in which the substrate surface area is dramatically increased. Such dramatic increases in surface area are useful in

forming devices for liquid phase analysis that employ, for example, one or more modes of separation as disclosed in the specification as filed on page 30, line 9 to page 31, line 3.

THE EXAMINER'S REJECTIONS

In the final rejection, mailed September 22, 2000, The Examiner rejected claims 23-27, 29-46, 48-50 and 52-59 under 35 U.S.C. 102(b) as anticipated by either one of Swedberg et al. or Kaltenbach et al., each originally submitted with an Information Disclosure Statement by the appellants. To support these rejections, the Examiner asserted that laser ablative techniques are disclosed in each document as preferred methods to provide a high surface texturing of the substrate through a subtractive process. The Examiner characterized the claims as drawn to a high-surface area textured substrate prepared by a subtractive process to produce high-surface area texturing of the surface and thus asserted that each claim is anticipated. Moreover, the Examiner stated that inherency is relied upon in issuing a combination rejection under 35 U.S.C. §102/103. That is, the Examiner characterized laser ablative techniques as inherently providing high-surface area texturing of the substrate through a subtractive process.

The Examiner added that he does not have laboratory facilities with which to measure the surface roughness and corresponding surface area of the substrate of the prior art. Thus, the Examiner contended that "it is incumbent on the applicants to rebut the Examiner's allegation of inherency based on Swedberg et al. or Kaltenbach et al. with comparative evidence showing that the teaching of the prior art relied upon by the Examiner do not anticipate and/or render the scope of the protection sought prima facie obvious."

In response, Appellants submitted on November 21, 2000, the Declaration of Dr. Reid A. Brennan, one of the joint inventors of the subject matter sought to be patented. The Declaration included comparative evidence in the form of two scanning electron micrographs, one illustrating a typical laser-ablated channel having a substantially defect-free surface (see FIG. 11) and another illustrating an imperfectly formed microchannel (see FIG. 12). As stated in paragraph 8 of the Declaration, these figures illustrate laser-ablated channels as generally described in Swedberg et al. and Kaltenbach et al. However, the Examiner maintained his rejection in the Advisory Action.

ISSUES

As a result, all pending claims, i.e., claims 23-27, 29-46, 48-50, 52-69, 77 and 78, are on appeal. In particular, Appellants intend to address two main issues in this appeal. The first issue is whether the cited art, Swedberg et al. or Kaltenbach et al., either expressly or inherently teach the inventive subject matter of the claims. The second issue is whether the differences between the claimed invention and the subject matter of the cited art are such they would have been obvious as of the filing date of the application or earlier.

GROUPING OF CLAIMS

The claims on appeal are grouped as follows:

- (1) claims 23-27, 29-35, 39-43, 46, 77 and 78 drawn to a high surface area textured substrate;
- (2) claims 36-38, drawn to a high surface area textured substrate prepared using a grayscale mask;
- (3) claims 44 and 45, drawn to a high surface area textured substrate prepared using homogeneous texturing or heterogeneous texturing (including continuous heterogeneous texturing and discontinuous texturing);
- (4) claims 48-50, 52-58, 62-66 and 69, drawn to a miniaturized analysis device;
- (5) claims 59-61, drawn to a miniaturized analysis device prepared using a grayscale mask; and
- (6) claims 67 and 68, drawn to a miniaturized analysis device prepared using homogeneous texturing or heterogeneous texturing (including continuous heterogeneous texturing and discontinuous texturing).

The claims of each group stand or fall together.

THE CITED REFERENCES

In rejecting the claims, the Examiner relied on two patents, Swedberg et al. and Kaltenbach et al. Both patents relate to miniaturized analytical devices that handle liquid samples. In issuing the rejections, the Examiner does not point out the particular sections of the patents on which he relies, but rather generally asserts that "since laser ablative techniques are

shown within the metes and bounds of these documents ... a high surface texturing of the substrate through a subtractive process [is disclosed]." These patents are briefly summarized below.

Swedberg et al. is directed to a fully integrated miniature planar liquid sample handling and analysis device. In particular, the invention relate to miniaturized planar column technology for liquid phase technology. The patent discloses that the device may be produced by employing laser-ablation to remove material from a substrate other than silicon or silicon dioxide in order to form one or more microchannels therein. However, there is no disclosure with respect to using laser ablation to increase the surface area on a substrate surface or with respect to texturing. In fact, the word texturing does not appear anywhere in the patent. Furthermore, the only disclosure relating to a high surface area portion of the device relates to the sample treatment component that may be "loaded with a matrix having a high surface area." *See* column 33, lines 29-34.

Kaltenbach et al., is directed to miniaturized planar columns in novel support media for liquid phase analysis. Like Swedberg et al., this patent discloses that the device may be produced by employing laser-ablation to form microchannels on a substrate surface. Similarly, this patent makes no mention of texturing or of surface area increase through material removal from the substrate.

ARGUMENT

I. THE HIGH-SURFACE AREA SUBSTRATE CLAIMED BY APPELLANTS IS NOVEL OVER EACH OF THE CITED PATENTS.

The first issue on appeal is whether the cited art teaches the inventive subject matter of the claims. It is well settled that anticipation requires a showing that all elements of a claimed invention are disclosed in a single prior art reference. *In re Bond*, 15 USPQ2d 1566, 1567 (Fed. Cir. 1990). As the following will demonstrate that the inventive high surface-area substrate is neither expressly or inherently disclosed, neither Swedberg et al. nor Kaltenbach et al. anticipates the pending claims.

A. NEITHER SWEDBERG ET AL. NOR KALTENBACH ET AL. EXPRESSLY DISCLOSES THE CLAIMED SUBSTRATE.

In order for either cited patent to expressly anticipate the rejected claims, there must be disclosure with respect to every element of each claim. As discussed above, neither Swedberg et al. nor Kaltenbach et al. makes any express disclosure with respect to high-surface area texturing. That is, neither patent makes any disclosure with respect to an increase in surface area by at least 10-fold to 100,000-fold. Since independent claim 23 recites a surface area increase of at least 10-fold to 100,000-fold as a claim element, neither claim 23 nor the claims depending therefrom are expressly anticipated by the cited patents.

Furthermore, it should be noted that the claims depending from claim 23 recite other elements that are not disclosed in either Swedberg et al. or Kaltenbach et al. For example, while use of a grayscale mask is recited in dependent claims 36-38 and 59-61, there is no disclosure in either cited patent with respect to the use of a grayscale mask. Thus, use of a grayscale mask is a novel aspect of the inventive subject matter that provides an independent basis for patentability with respect to claims 36-38 and 59-61. Similarly, neither cited patent teaches homogeneous or heterogeneous texturing, yet such texturing is recited in dependent claims 44, 45, 67 and 68. Homogeneous texturing is another novel aspect that provides an independent basis for patentability with respect to these dependent claims. Thus, these additional elements support the proposition that, as a general matter, the cited patents do not expressly anticipate the claims depending from the independent claims. In addition, this in line with the Examiner's statement in the Office Action mailed May 22, 2000 that "all specific limitations may not be specifically pointed out or distinctly claimed within the metes and bounds of the [prior art] documents."

B. THE CLAIMED SUBSTRATE IS INHERENTLY DISCLOSED IN NEITHER CITED REFERENCE.

Appellants also respectfully disagree with the Examiner's contention that inherency is a proper basis for this rejection. The so-called doctrine of inherency provides that a prior art reference can anticipate and thus invalidate a claim "by inherency" where it would be appreciated by one of ordinary skill in the art. *Continental Can Co. USA v. Monsanto Co.*, 20 USPQ2d 1746 (Fed. Cir. 1991); *Glaxo, Inc. v. Novopharm Ltd.*, 34 USPQ2d 1565 (Fed. Cir. 1995). A corollary of the inherency doctrine is that a patent claim to a process is anticipated by a

prior art reference that discloses all of the limitations of the claim even though the reference does not expressly disclose the "inventive concept" or desirable property supposedly discovered by the patentee. It suffices that the prior art process inherently possessed that property. See *Verdegaal Brothers, Inc. v. Union Oil Company of California*, 2 USPQ 2d 1051 (Fed. Cir. 1987). However, it is also settled law that "[t]he mere fact that a certain thing *may result* from a given set of circumstances is insufficient to prove anticipation." *Electro Medical Systems, S.A. v. Cooper Life Sciences, Inc.*, 34 F.3d 1048, 32 USPQ 1017 (Fed Cir. 1994). Thus, the critical issue in inherency analysis is whether **it necessarily follows** that all elements of the claims are inherently disclosed in the cited references even though not all elements are expressly disclosed. In carrying out an anticipation-by-inherency analysis for this case, the critical issue is whether laser ablative removal of material from a substrate **necessarily results** in surface texturing and an increase in surface area by 10-fold to 100,000-fold.

Appellants again submit that disclosure with respect to laser ablative removal of material from a substrate surface does not inherently disclose an increase in surface area. For example, laser ablation may be employed to flatten an irregular, uneven or rough surface, thereby producing a smooth surface having a reduced area. Thus, depending on the original surface of a substrate, forming features such microchannels on a surface through laser ablation removal does not necessarily increase the surface area of the substrate surface. It should be also evident that forming channels in a substrate surface through laser ablation does not always increase the area of the substrate surface by 10-fold to 100,000-fold as is required by the pending claims.

In addition, laser ablation does not inherently require the use of a grayscale mask and may result in homogeneous, heterogeneous or no texturing at all. From simple geometric considerations, it should be evident that removing material from a solid form always reduces the volume of the form, and the smaller of two solid forms having the same shape will have a smaller surface area. Thus, neither Swedberg et al. nor Kaltenbach et al. inherently discloses high-surface area texturing or a method that dramatically increases the surface area of a substrate through a subtractive process as the Examiner contended.

II. THE HIGH-SURFACE AREA SUBSTRATE CLAIMED BY APPELLANTS IS NONOBVIOUS OVER EACH OF THE CITED PATENTS.

The pending claims were alternatively rejected as obvious over either one of Swedberg et al. or Kaltenbach et al. The Examiner stated that each of these two references renders the independent claim *prima facie* obvious, but that "all specific dependent claim limitations may not be specifically pointed out or distinctly claimed" in the cited patents. Nevertheless, the Examiner asserted that such limitations are also *prima facie* obvious modifications to the generic teachings absent objective evidence of high probative value to the contrary.

To establish *prima facie* obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the reference(s) themselves or in the knowledge generally available to one of ordinary skill in the art, to modify a reference's teaching. Second, there must be a reasonable expectation of success, and third, the prior art reference must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on an appellant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). In this instance, the three criteria have not been met.

The first criterion has not been met because the Examiner has cited no reason why one of ordinary skill in the art would modify the teaching of either Swedberg et al. or Kaltenbach et al. to increase the area of a substrate surface. As discussed above, neither patent expressly or inherently discloses a surface area increase. Moreover, the word "texture" does not even appear in either Swedberg et al. or Kaltenbach et al. Thus, the Examiner has employed improper hindsight analysis in issuing this rejection because there is no reason given as to why a reference disclosing laser ablation must be read as suggesting texturing through an increase in surface area, without prior knowledge of appellants' invention.

Moreover, neither Swedberg et al. nor Kaltenbach et al. suggests all claim limitations. As now amended, claim 23 and the claims depending therefrom require a surface area increase of **at least 10-fold to 100,000-fold**. This means that the claims require a substantial surface area increase of **at least one to five orders of magnitude**. It would not be obvious in view of either Swedberg et al. or Kaltenbach et al. to increase surface area by such a great extent. In addition, as discussed above, texturing is not involved in either Swedberg et al. or Kaltenbach et al. For the above reasons, *prima facie* obviousness has not been established, and the rejection is in error.

In addition, the Examiner did not consider the cited patents in their entirety as is required in every obviousness analysis. *In re Hedges*, 228 USPQ 685 (Fed. Cir. 1986). For example, Swedberg et al. only discloses the use of laser ablation for forming features such as sample processing channels and apertures, not laser ablation for texturing. *See* column 14, lines 42-45. It is also disclosed that in a preferred embodiment, such channels are made having a semicircular cross-sections, and the channels may be used to form sample processing chambers having a highly symmetrical circular cross section that may be desirable for enhanced fluid flow. *See* column 14, lines 59-67. Thus, it is evident that laser ablation as disclosed in the cited patents is generally used to form smooth and regular features in microanalytical devices, not for texturing or increasing surface area. This certainly does not render obvious an increase of surface area by at 10-fold to 100,000-fold as is now recited by the claims. Smooth surfaces are generally antithetical to a surface area increase. Moreover, even if a surface area increase were taught, the cited patents do not suggest an increase in surface area to such a large extent.

Appellants direct the Board to FIG. 4A-H of the application. These figures are scanning electron micrographs of a Kapton® sheet laser ablated through various grayscale masks and exemplify surfaces having undergone the inventive texturing process. As is evident from these micrographs, material is removed from a generally rectangular section of the surface of the sheet through laser ablation. The surface within the rectangular section exhibits high surface-area texturing. As described on page 33, lines 8-13, the high surface area exhibited by these examples is achieved through "coning," a process in which cones are produced on a polymeric surface through laser ablation. While the particular degree of surface area increase has not been precisely measured, it is evident that a visual comparison of the unablated and ablated portions of the substrate surface indicates an enormous increase in surface area due to coning as a result of ablation. According to the declaration submitted in response to the final rejection, inventor Dr. Reid Brennen estimates that the surface area of the ablated portion of the surface in all figures submitted is at least about one to five orders of magnitude greater than the corresponding unablated portion.

With respect to the Examiner's assertion that such an increase in surface area is obvious, applicants again direct the Board to the declaration submitted in response to the final rejection. Prior use of laser ablation in order to form channels does not result in the invention as claimed. As shown in the FIG. 11 contained in Appendix B of the declaration, laser ablation of Kapton®

sheets in order to form channels, as generally described in Kaltenbach et al. and Swedberg et al., results in generally smooth channel surfaces. Smooth channel surfaces do not necessarily exhibit the degree of surface area increase required by the claimed invention. Thus, obviousness is an improper basis for rejecting the pending claims. While a flawed ablation process may sometimes result in small surface imperfections and slight coning (*see, e.g.*, FIG. 12), such imperfections increase surface area by only a trivial amount. Such a trivial increase in surface area does not suggest an increase in surface area by at least 10-fold to 100,000 fold as is now claimed. In short, neither cited reference suggest the inventive subject matter of any of the rejected claims, independent or dependent.

Thus, the Examiner erred when he stated in the Advisory Action that "the closest prior art of record has not been utilized for comparison purposes." The submission of FIGS. 11 and 12, the micrographs of the channels formed through laser ablation as generally described in Kaltenbach et al. and Swedberg et al., provides a basis for visual comparison with the textured surfaces produced through laser ablation as illustrated in FIGS. 4A-H. The differences between the claimed invention and the subject matter of the cited art can be ascertained by performing such a visual comparison. In viewing these micrographs, the Board should further note that Sally Swedberg is a joint inventor of this application as well as the cited patents. Thus, it is puzzling why the Examiner summarily dismissed Dr. Brennen's Declaration containing FIGS. 11 and 12 as failing to utilize the closest prior art of record for comparison purposes. Without employing hindsight, one of ordinary skill in the art would not have viewed the textured surface illustrated in FIGS. 4A-H as an obvious variation of the surface of the channels illustrated in FIGS. 11 and 12. The dramatic difference between the texture of the surfaces as well as the increase in surface area is simply too extensive to be characterized as a mere variation of art known to one of ordinary skill.

Further, appellants submit that the Examiner erred in summarily rejecting the dependent claims. The Examiner has in fact admitted that "all specific dependent claim limitations may not be specifically pointed out or distinctly claimed; see Office Action mailed May 22, 2000. The Examiner cited no reference that suggests either the use of a grayscale mask or homogeneous or heterogeneous texturing. Nor does the Examiner state why one of ordinary skill in the art would be motivated to modify the teachings of either Swedberg et al. or Kaltenbach et al. by employing a grayscale mask or to achieve homogeneous or heterogeneous texturing. Thus, the improper use

of hindsight was apparently employed with respect to the rejection of dependent claims 36-38, 44, 45, 59-61, 67 and 68, and the rejection of these claims is unwarranted, regardless of the patentability of the independent claims from which these claims depend.

Accordingly, reversal of the Examiner's rejections is respectfully requested.

CONCLUSION

Appellants respectfully submit, in conclusion, that the claims now on appeal define an invention that is novel and nonobvious over the cited art. Accordingly, appellant request reversal of the Examiner's rejection under sections 102(b) and 103(a) of Title 35 of the United States Code.

Respectfully submitted,

March 15, 2001
Date

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APPENDIX (CLAIMS ON APPEAL)

23. A high-surface area textured substrate prepared by a process comprising subtracting material from, adding material to, or both subtracting material from and adding material to a surface of a substrate having a surface area using a subtractive method, an additive method, or both subtractive and additive methods, respectively, to produce high-surface area texturing of the surface that results in an increase in the surface area by at least 10-fold to 100,000-fold.

24. The high-surface area textured substrate of claim 23, wherein the substrate is selected from the group consisting of polymeric materials, ceramic materials, glass materials, metal materials, composites thereof and laminates thereof.

25. The high-surface area textured substrate of claim 23, wherein the substrate is a laser-ablatable substrate.

26. The high-surface area textured substrate of claim 25, wherein the laser-substrate comprises a polyimide.

27. The high-surface area textured substrate of claim 23, wherein the method is a subtractive method.

29. The high-surface area textured substrate of claim 27, wherein the subtractive method is a lithographic method.

30. The high-surface area textured substrate of claim 29, wherein the lithographic method is selected from the group consisting of a direct feature definition method, an intrinsic feature definition method, a secondary masking method, a deposit-and-pattern method, and combinations thereof.

31. The high-surface area textured substrate of claim 30, wherein the lithographic method is a direct feature definition method.

32. The high-surface area textured substrate of claim 30, wherein the lithographic method is an intrinsic feature definition method.

33. The high-surface area textured substrate of claim 32, wherein the feature definition method comprises exposing the surface of a laser-ablatable substrate to a source of laser light.

34. The substrate of claim 33, wherein a laser ablation mask is used to define a pattern of laser light incident on the surface of the substrate.

35. The substrate of claim 34, wherein the laser ablation mask is selected from the group consisting of a laser-light transmissive material comprising laser-light opaque material applied thereto, a laser-light transmissive material comprising laser-light partially transmissive material applied thereto, a laser-light transmissive material comprising laser-light opaque material embedded therein, a laser-light transmissive material comprising laser-light partially transparent material embedded therein, or a laser-light transmissive material comprising a combination of laser-light opaque material applied thereto, laser-light partially transmissive material applied thereto, laser-light opaque material embedded therein, and laser-light partially transparent material embedded therein.

36. The substrate of claim 35, wherein the laser ablation mask is a dot grayscale mask, a line-and-space grayscale mask or a combination thereof.

37. The substrate of claim 36, wherein the laser ablation mask is a dot grayscale mask comprising dots selected from the group consisting of opaque dots, transmissive dots, partially transmissive dots, and combinations thereof.

38. The substrate of claim 36, wherein the laser ablation mask is a line-and-space grayscale mask comprising lines selected from the group consisting of opaque lines, transmissive lines, partially transmissive lines, and combinations thereof.

39. The substrate of claim 33, wherein the exposing of the surface of the substrate is selected from the group consisting of scanning the source of laser light over the surface of the substrate, exposing the surface to laser light using a step-and-repeat protocol, subjecting the substrate to multiple exposures of laser light, and combinations thereof.

40. The substrate of claim 39, wherein a laser ablation mask is used to define a pattern of laser light incident on the surface of the substrate.

41. The substrate of claim 40, wherein the substrate is subject to multiple exposures of laser light and for each of the multiple exposures, the same or a different laser ablation mask, or a combination thereof, is used to define the pattern of the light incident on the surface of the substrate.

42. The substrate of claim 33, wherein a selected area of the substrate is exposed to the source of laser light.

43. The substrate of claim 42, wherein a laser ablation mask is used to define a pattern of laser light incident on the surface of the substrate.

44. The substrate of claim 43, wherein the high-surface area texturing is homogeneous texturing or heterogeneous texturing.

45. The substrate of claim 44, wherein the high-surface area texturing is heterogeneous texturing and further wherein the heterogeneous texturing is selected from the group consisting of continuous heterogeneous texturing and discontinuous texturing.

46. The substrate of claim 27, wherein the subtractive method is a nonlithographic method selected from the group consisting of a laser-assisted chemical etching method and a local roughening method

48. A miniaturized analysis device prepared by a process comprising subtracting material from, adding material to, or both subtracting material from and adding material to the surface of a substrate using a subtractive method, an additive method, or both subtractive and additive methods, respectively, to produce high-surface area texturing of the surface.

49. The miniaturized analysis device of claim 48, wherein the substrate is selected from the group consisting of polymeric materials, ceramic materials, glass materials, metal materials, composites thereof and laminates thereof.

50. The miniaturized analysis device of claim 48, wherein the method is a subtractive method.

52. The miniaturized analysis device of claim 50, wherein the subtractive method is a lithographic method.

53. The miniaturized analysis device of claim 52, wherein the lithographic method is selected from the group consisting of a direct feature definition method, an intrinsic feature definition method, a secondary masking method, a deposit-and-pattern method, and combinations thereof.

54. The miniaturized analysis device of claim 53, wherein the lithographic method is a direct feature definition method.

55. The miniaturized analysis device of claim 53, wherein the lithographic method is an intrinsic feature definition method.

56. The miniaturized analysis device of claim 55, wherein the feature definition method comprises exposing the surface of a laser-ablatable substrate to a source of laser light.

57. The miniaturized analysis device of claim 56, wherein a laser ablation mask is used to define a pattern of laser light incident on the surface of the substrate.

58. The miniaturized analysis device of claim 57, wherein the laser ablation mask is selected from the group consisting of a laser-light transmissive material comprising laser-light opaque material applied thereto, a laser-light transmissive material comprising laser-light partially transmissive material applied thereto, a laser-light transmissive material comprising laser-light opaque material embedded therein, a laser-light transmissive material comprising laser-light partially transparent material embedded therein, or a laser-light transmissive material comprising a combination of laser-light opaque material applied thereto, laser-light partially transmissive material applied thereto, laser-light opaque material embedded therein, and laser-light partially transparent material embedded therein.

59. The miniaturized analysis device of claim 58, wherein the laser ablation mask is a dot grayscale mask, a line-and-space grayscale mask or a combination thereof.

60. The miniaturized analysis device of claim 59, wherein the laser ablation mask is a dot grayscale mask comprising dots selected from the group consisting of opaque dots, transmissive dots, partially transmissive dots, and combinations thereof.

61. The miniaturized analysis device of claim 59, wherein the laser ablation mask is a line-and-space grayscale mask comprising lines selected from the group consisting of opaque lines, transmissive lines, partially transmissive lines, and combinations thereof,

62. The miniaturized analysis device of claim 56, wherein the exposing of the surface of the substrate is selected from the group consisting of scanning the source of laser light over the surface of the substrate, exposing the surface to laser light using a step-and-repeat protocol, subjecting the substrate to multiple exposures of laser light, and combinations thereof.

63. The miniaturized analysis device of claim 62, wherein a laser ablation mask is used to define a pattern of laser light incident on the surface of the substrate.

64. The miniaturized analysis device of claim 63, wherein the substrate is subject to multiple exposures of laser light and for each of the multiple exposures, the same or a different laser ablation mask, or a combination thereof, is used to define the pattern of the light incident on the surface of the substrate.

65. The miniaturized analysis device of claim 56, wherein a selected area of the substrate is exposed to the source of laser light.

66. The miniaturized analysis device of claim 65, wherein a laser ablation mask is used to define a pattern of laser light incident on the surface of the substrate.

67. The miniaturized analysis device of claim 66, wherein the high-surface area texturing is homogeneous texturing or heterogeneous texturing.

68. The miniaturized analysis device of claim 67, wherein the high-surface area texturing is heterogeneous texturing and further wherein the heterogeneous texturing is selected from the group consisting of continuous heterogeneous texturing and discontinuous heterogeneous texturing.

69. The miniaturized analysis device of claim 50, wherein the subtractive method is a nonlithographic method selected from the group consisting of a laser-assisted chemical etching method and a local roughening method.

77. The substrate of claim 23, wherein the increase in the surface area is at least 1,000-fold to 100,000-fold.

78. The substrate of claim 77, wherein the increase in the surface area is at least 10,000-fold to 100,000-fold.